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SOURCE Radio, No 4, 1951, pp 18-22.THE TULA BATTERY RECEIVER

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The designers of the Tula receiver, described in this report, were awarded first prize in the Ministry of Communications competition in the design of equipment for rural radiofication. A schematic diagram of the receiver is appended.

Because their price and operating expenses must be kept down, ~~mass-produced~~ battery receivers are more difficult to design than second-class or even first-class radios in which standard units and parts can be used. Since the unit cost of power in a third-class battery receiver is three to four times that of a first-class line receiver, it can be readily understood why economic considerations still must be taken into account in battery receiver design.

The requirements for a cheap, mass-produced battery radio are:

Loud-speaker reception of local and neighboring stations must be at least equal in quality and volume to that provided by wired radio centers.

The initial price should not be much higher than that of a loud-speaker for a wired radio center and the operating costs should not exceed the price of a subscription to the center.

If battery or tubes fail, provision should be made for crystal-set operation or for connection to the wired radio network.

Maintenance must be very simple.

The Tula battery receiver satisfies all these requirements.

Circuit

In the schematic diagram of the Tula receiver, as seen in the appended figure, two miniature tubes, the 1B1P and 2P1P, are used. The former operates as a grid detector and an amplifier (the diode section is not used), while the latter acts as

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an output tube and phase-inverter for regeneration. This is the minimum number of tubes capable of ensuring good reception from local and neighboring stations with an outdoor antenna. Only one tuned circuit, directly connected with the antenna, is used. To increase selectivity and amplification, feedback is provided from the plate circuit of the second tube through the small semivariable capacitor  $C_{10}$ .

This regenerative circuit needs no special feedback coil or supplementary taps on the tuned circuit; hence, the band switch can be greatly simplified. Moreover, this circuit does not permit one to look for a station while the receiver is oscillating (as is the case with most regenerative receivers), thereby indirectly preventing spurious transmission from the receiver. This is accomplished, at the threshold of oscillation, by the simultaneous generation of oscillations which blanket all incoming signals, making it impossible to tune in a station.

Thus, the main defect of regeneration, i.e., the possibility of interference with nearby radios, is eliminated, while its good qualities are retained. The regenerative control consists of a screw-driver adjustment on the back of the cabinet.

Uniform amplification at various points of the band is obtained by proper selection of the parameters for the compensation circuits  $L_5$ - $R_7$  and  $R_8$ - $C_7$ .

A differential capacitor  $C_9$  is connected between the tuned circuit and the control grid of the first tube to regulate the volume.

The circuit is tuned by an "al'sifer"  $[Al-Si-Fe]$  core, which passes successively through coils  $L_1$ ,  $L_2$ ,  $L_3$  and  $L_4$ , wound on one form. The sliding contact of the band switch moves with the core along the coil form. The taps of the coils going to the chassis are used for switching, and therefore, the friction of the band switch does not cause crackling and noise.

The jacks to connect the output transformer with the wired radio network are connected in parallel with its primary winding.

For use as a crystal receiver, special jacks are provided to connect up the crystal detector (D in appended figure) and the headset (T in appended figure).

#### Design

The main unit is the loud-speaker because its dimensions determine the shape and size of the cabinet. The Tula speaker has a cone one and one half times larger than the speakers in ordinary cheap radios. Consequently, its efficiency is increased and its frequency response smoothed because of the more effective reproduction of the medium and low frequencies.

The front panel serves both to support the cone and to brace the field coil. In the lower part of the cabinet there is a panel on which the tube sockets, output transformer, circuit coils, capacitors, and resistors are arranged. Two very similar cabinet types can be used.

The most original part of the receiver is the combination of all controls in one knob on the front panel. When the knob is lifted up, it switches in the battery, actuates the mechanism which shows that the power is on, and regulates the volume and feedback. Smooth tuning and band-switching are obtained by moving the knob horizontally.

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The method of construction is described below. Parallel to the coil form there is a rectangular metal bar along which a carriage (an extension of the control knob) can move. Attached to the carriage there is a flexible cord which passes through the roller into the coil form where the movable "alloy" core, connected at both ends with the cord, is located. A sliding contact of the band switch, made in the form of a flexible hemisphere, is fastened to this carriage. When the carriage is moved, the contact passes successively along the metal contact strips which are fastened to the panel and to which the ends of the coil are connected.

A metal plate acting as one of the differential capacitor plates is attached at the extreme right end of the bar; the plate is connected to the grid side of the tuned circuit. When the control knob is raised, the horizontal bar rotates through a certain angle and the movable plate approaches the plate fastened to the receiver panel and connected to the control grid of the first tube. The change in capacitance between these two plates regulates the volume.

Also at the right end of the bar is a system of levers which actuates the supply switch and signal.

Flat clamps are placed on the back edge of the panel for connecting the antenna and ground, the headset, and the wired radio line.

All the parts are designed for mass production, the great majority being stamped. There are practically no turned parts or screws. The amount of metal and other material used is likewise very small. The total weight of the Tula is 1.6 kg, whereas the R-912 weighs almost 3.5 kg.

#### Supply

The supply system was designed to provide maximum life for tubes and batteries. Research has shown that miniature tubes can operate quite effectively with a filament current of 45-50 ma with low cathode emission and low plate voltage. The life of a tube under these operating conditions is greatly increased, and the battery load is lightened. The 3S cells used to supply the filaments have a capacity of 30 amp-hr when discharged through a 10  $\Omega$  resistance. However, if the discharge current is reduced to one half or one third, their capacity will be doubled in operation under intermittent discharge conditions. The filaments of the tubes are connected in series. Two series-connected 3S cells provide an initial filament current of 50 ma. After the radio has been operating for 2 to 2½ mo (for 3 to 4 hr per day), the cell voltage will drop to 2.2-2.3 v. Thereafter, one half of the 2P1P filament is shorted by a switch and the receiver begins to operate under economical conditions. This type of filament supply also has the advantage of eliminating the need for a filament rheostat.

A BAS-G-60 battery is used as a plate-voltage source. Under intermittent discharge with current less than 3.5 ma, this battery will give long service, i.e., at least as long as the filament battery made up of 3S cells under the operating conditions described above.

To prevent the tube filaments from burning out through unskillful handling, both the filament and plate batteries are enclosed in one case. To this case is fastened a tube-type socket with jacks, into which the receiver plug is connected. The plug can be inserted in the jacks only in one definite position; thus the plate voltage cannot possibly be applied to the tube filaments.

Operational tests of this battery unit with the receiver showed that its life exceeded 1,000 hr.

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The receiver can operate on even lower voltages. For example, it operates with satisfactory volume at a plate voltage of 30 v and a filament voltage of 1.5 v. One of the advantages of a straight tuned rf amplification circuit is that the supply voltages are not critical.

For the supply voltages first mentioned, the sensitivity and volume of the Tula are adequate. If these voltages are raised 50%, that is, up to 4 v for the filament (three 3S cells) and 80 v for the plates (BAS-80 battery), the electroacoustic characteristics will be greatly improved, while the operating conditions for the tubes remain within their established norms. In this case, however, operating expenses will be somewhat higher. Preliminary calculations indicate that the operating costs of the receiver plus the subscription license fee will be considerably less than the subscription fee established for the use of a wired radio loud-speaker.

<u>Parameters of the Tula</u>	<u>Units</u>	<u>Norms According to Specifications</u>	<u>Results of Tests</u>
Current consumption from supply source			
In plate circuits when $E_p = 60$ v	ma	4.5	3.4-3.6
In filament circuits when $E_f = 3$ v	ma	60	50
Frequency bands			
Medium wave	kc	535-1500	500-1600
Long wave	kc	150-410	117-415
Sensitivity at average sound pressure of 1.3 dynes per sq cm at a distance of 1 m	mv	40	11-37
Manual volume control range	db	20	20
Variation of frequency response in frequency range of 200-3,500 cps			
In entire unit	db	20	14-15
In loud-speaker	db	—	12-15
Harmonic content with respect to sound pressure	%	15	4.5-11
Mean sound pressure of speaker in range of 200-2,000 cps for 0.1 va in field coil	bar	2.3	4-4.3

#### Results of Tests

Models of the Tula have been tested under normal operating conditions in kolkhozes 150-200 km from Moscow with antennas 15-20 m long, suspended at a height of about 10 m. The volume of reception from all three Moscow stations was more than adequate in small rooms. With more regeneration, satisfactory reception could be obtained from other cities (Leningrad, Minsk).

The tests showed the convenience of the control arrangements. In places where just one station could be heard, the receiver operated practically like a push-button radio, since, with fixed tuning, it was only necessary to move the knob up and down for switching on and off and for volume control.

A year's trial also demonstrated the economical operation of the receiver and the long life of the tubes for the supply voltages mentioned previously.

The manufacture of the first series of Tula radios in 1951 and their use under varied conditions will enable listeners and amateurs to make suggestions for improving the operational and acoustic properties of the receiver. It should become the most widely used radio in nonelectrified rural areas.

Appended diagram follows:

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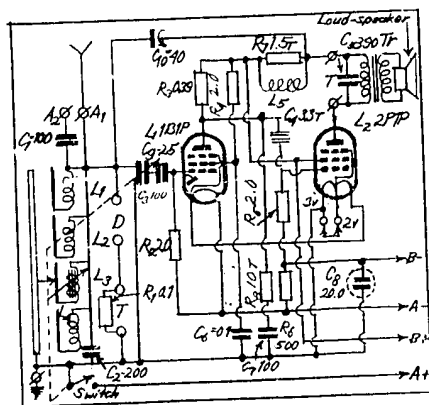


Figure 1. Schematic Diagram of the Tula Receiver

In this diagram, as in all other diagrams used in the periodical Radio, the following coding of resistors and capacitors is used: C 65 =  $65 \mu\mu f d$ , C 3T =  $3,000 \mu\mu f d$ , C 5.5T =  $5,500 \mu\mu f d$ , C 0.3 =  $0.3 \mu\mu f d$ , C 4.0 =  $4 \mu\mu f d$ , R 800 =  $800 \Omega$ , R 40T =  $40,000 \Omega$ , R 0.2 =  $0.2 M\Omega$ , R 2.0 =  $2 M\Omega$ .

Thus, in the given diagram,  $C_1 = 100 \mu\mu f d$ ,  $C_6 = 0.1 \mu\mu f d$ ,  $R_2 = 2 M\Omega$ ,  $R_3 = 390,000 \Omega$ ,  $R_7 = 1,500 \Omega$ , etc.

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